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*Winter School on*  
Impact of Climate Change  
on Indian Marine Fisheries

*Lecture Notes*

Part 1

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### **Introduction**

Biodiversity plays a decisive role in maintaining the ecological balance of the earth. Towards the end of the 20<sup>th</sup> century, humankind grew conscious of its unprecedented impact upon natural environments and the danger of exhausting biological resources. Therefore, biodiversity emerged as an environmental issue in the early 1980s, culminating in the Conference on Sustainable Development held in Rio de Janeiro in 1992. At the same time, biological diversity was recognized as an essential parameter, in particular for the agro and pharmaceutical industries. This raised ethical questions about the conservation of biological diversity and patenting of living beings. Further, biodiversity became a framework for considering and discussing the whole range of questions raised by human relationships with other species and natural environments – a kind of ‘mediator’, as it were, between ecological systems and social systems. Independently of this new role, biodiversity remains as one of the major concerns relative to global environment.

Though most of the world’s surface is sea, only 15 percent of the world’s recorded species inhabit the sea. However, 32 out of 33 phyla are in the sea. Around 28,000 species of fishes are known to inhabit different trophic levels in the sea. This reveals the vital role marine biodiversity plays in maintaining the health and stability of earth’s environment. Thus biodiversity is ‘Life on Earth’ in its most simple form. Marine biodiversity is therefore ‘All life in the seas and oceans’. It refers to a variety of life forms including plants, animals and microorganisms, the genes that they contain, the ecosystems they form and habitats they occur.

### **Marine wealth of India**

India’s wealth of biodiversity is found in highly diverse marine and coastal habitats. Until today marine diversity is less known than terrestrial biodiversity due to the logistic difficulties of explorations, underwater surveys and collections. With 8129 km of coastline, 200 km wide Exclusive Economic Zone, the bay islands of Andaman & Nicobar and the atoll island group of Lakshadweep, in India, astonishingly we know little about marine life even in the most familiar seascapes. The Indian Ocean accounts for 29% of the global oceans, 13% of the marine organic carbon synthesis, 10% of the capture fisheries, 90% of the culture fisheries, 30% of the local reefs, and 10% of mangroves. India has 246 estuaries draining a hinterland greater than 200 km<sup>3</sup> besides coastal lagoons, mangroves and backwaters.

Research on marine bio-resources in India dates back to the 18<sup>th</sup> century, which initially started with surveys and expeditions conducted by the westerners, particularly by the British. This initiative has blossomed further and has witnessed advancements in marine research, in parallel to the developed nations. It is pertinent to note that among the Asian countries, India is perhaps the only one that has a long record of inventorisation of marine biodiversity so far. Investigation of fauna and flora have been conducted along the mainland coasts where some of the premier research institutes and universities are located. Further, many institutions administered under the Ministry of Environment and Forests (MoEF), Department of Ocean Development (DOD), Department of Science and Technology (DST), Department of Biotechnology (DBT), Department of Space (DoS), Council of Scientific and Industrial Research (CSIR), Indian Council of Agricultural Research (ICAR), Universities under the network of the University Grants Commission (UGC), Science, technology and environment departments in various states, non-governmental organisations like Bombay Natural History Society (BNHS), M.S. Swaminathan Research Foundation (MSSRF) and others are currently involved in diverse fields of research and development in India’s marine biodiversity.

Microorganisms represent the largest reservoir of biodiversity. A paper “Recent advances in marine microbiology: the Indian scenario” gives a clear picture of microbes of the seas which includes mycological and bacteriological aspects covering near, offshore and deep-sea waters (Chandramohan, 1997).

Among Plantae, marine phytoplankton, the pastures of the sea, are the major sustaining components of ecosystem processes and responsible for the biogeochemical reactions that drive our climate changes. Apart from the substantial contributions of NIO and Universities, CMFRI has played a major role in the investigations on phytoplankton, since its inception in 1947. Initially, 156 species belonging to 15 families and 64 genera of Bacillariophyceae were listed by Subrahmanyam (1946). Subsequently, Subrahmanyam (1958, 1959) published an account of 365 species of phytoplankton of the Arabian Sea, comprising 226 species belonging to 67 genera of diatoms; 121 species of 67 genera of Dinophyceae, and 19 species of 14 genera of other microalgae. Later a detailed taxonomic appraisal was given on Dinophyceae of the Indian waters (1968 & 1971); 67 species were reported for the genus *Ceratium* and 114 species of the family Peridiniaceae under 7 genera. Gopinathan (1975) and Gopinathan and Pillai (1975) published 33 diatom species of 22 genera belonging to 12 families, and 25 species of Dinophyceae of 11 genera under 8 families from the sea off Cochin. Subsequently, 109 diatom species of 40 genera under 13 families were registered from the southwest coast of India (Gopinathan, 1984). Altogether over 800 species of phytoplankton have been recorded for the Indian seas.

Marine macro-algae from Indian coasts have been well surveyed in the last few decades. The revised checklist of Indian marine algae by Oza and Zaidi (2000) has recorded 844 species (including forms and varieties) distributed among 217 genera. Recently Kaliaperumal and Kalimuthu (2004) have recorded 1153 species under 271 genera. Kannan *et al.* (1999) have recorded 14 species of seagrasses from the Indian seas among which *Thalassia* and *Syringodium* are dominant in coral reef areas. Studies made by Kathiresan (1999) revealed that a total of 39 mangrove species are known from India and this has been incorporated in an atlas entitled “Mangrove atlas and status of species of India”.

Out of the total 32 animal phyla, 15 are represented by the taxa in the marine ecosystem. They may constitute either migratory or resident species. The former includes pelagic crustaceans, coelenterates (medusae), molluscs, fishes, reptiles, birds and mammals. The zooplankton communities of the Indian Seas presented under phyla Chaetognatha, Arthropoda, Annelida, Cnidaria, Echinodermata, Hemichordata and Chordata have been studied in detail by CMFRI, NIO and universities to build up a data bank on relevant species and also to know the species inhabiting our waters and their habitats, seasonality and numerical abundance. Copepods are the most predominant among the zooplankton community and are most widely studied among the planktonic crustaceans contributing about 540 species in Indian waters. Bensam (1991) published an appraisal of the studies conducted so far on the early developmental stages of marine Osteichthyes in India with suggestions for future research. More than 380 species of fish larvae have been identified and listed till date.

The benthic macro fauna comprises of resident species of polychaetes, molluscs, sipunculids and mud-burrowing fishes. Among invertebrates, sponges, corals and echinoderms generally do not prefer estuarine ecosystem. Papers on the poriferan faunal diversity of India recorded 486 species. Venkataraman *et al.* (2003) lists a total of 218 species of hard corals under 60 genera and 15 families. Although 89 species are reported from the Indian seas, the studies by Thomas and Rani (1986) revealed that 31 species referable to 19 genera and 9 families are the most common among the Indian gorgonids. A total of 150 soft corals are reported to occur in India. Among echinoderms, Sastry (1998) has recorded 765 species. Further, James (2000) reported 200 species of holothuroidae in the seas around India. In the shallow waters within 20 m, 75 species have been recorded, of which 12 are commercially important.

In India, estuarine species diversity seems to be maximum among the molluscs. Appukuttan (1996) has recorded 3,271 species of molluscs distributed among 220 families and 591 genera, of which 1900 are gastropods, 1100 bivalves, 210 cephalopods, 41 polyplacophores and 20 scaphopods. Subsequently, 3370 species of molluscs have been recorded by Rao (1998) from marine habitats.

Another important taxa, Polychaeta are represented by about 250 species belonging to 97 genera under 38 families. Maximum diversity has been observed in the much-studied Hoogly-Matlah estuary (West Bengal). It has been reported that 1093 species representing 8.7 % of the global 12,620 species occur in India (Achary *et al.*, 2005). Meiofauna of Indian estuaries are flagellates, ciliates, nematodes, ostracods, harpacticoid copepods, rotifers, gastrotriches and arachnids.

Free swimmers or nekton are important components of marine biodiversity and constitute important fisheries of the world. The dominant taxa in the nekton are fish, others being crustaceans, molluscs, reptiles and mammals. Out of a total of 28,000 species, it has estimated that about 4,000 species occur in the Indian Ocean of which 2,546 species are available in the Indian Seas (Talwar, 1991). Majority of the nektonic species is found in the coastal waters. It is estimated that 40 species of sharks and 250 species of teleosts represented the oceanic fishes.

According to Venkataraman and Krishnamoorthy (1998), out of the 2934 species of crustaceans that have been reported so far, marine species contribute maximum (94.9%). Suseelan (1996) listed 150 species of decapod crustaceans from the Indian Seas. In this account he has recorded 118 species of prawns under 33 genera belonging to Penaeidea of which 63 species are littoral and 27 are deep-water forms. Among the 17 species and 6 genera of lobsters, 6 are deep-water species and 11 are from the littoral environments. Later, additions from the coastal waters have increased the number to 26 (Venkataraman and Wafar, 2005). Suseelan (1996) reported 640 species of marine crabs from India, of which 12 species are edible and support commercial fisheries. Later, Venkataraman and Wafar (2005) recorded 705 brachyuran crabs from the Indian Seas. The pioneering monograph of Kemp (1913) reported 97 species of stomatopod fauna from the Indo-Pacific region and 54 species from the Indian Seas.

Among reptiles, sea snakes and turtles are important and represented worldwide by 57 species. There are seven recognized species of sea turtles in the world, of which five species are reported in India. Four species of turtles – the oliveridley (*Lepidochelys olivacea*), green turtle (*Chelonia mydas*), leatherback (*Dermochelys coriacea*) and hawksbill (*Eretmochelys imbricata*) nest along the Indian coasts. There are a few reports of loggerhead (*Caretta caretta*) from Indian waters, but nesting beaches are not known (Rajagopal, 1996).

The seashore offers a variable feeding and breeding ground for a number of birds. From the available data it has been inferred that there are 12 families, 38 genera and 145 species, which occur in the coastal ecosystem.

Marine mammals belong to three orders, Sirenia, Cetacea and Carnivora. About 120 species are estimated to occur in the world oceans and of these 26 are reported from the seas around India.

### **Conservation status, threats and problems**

India is a signatory to various International instruments and conventions related to the marine environment, notable of which are the UNCLOS, IWC, CBD and CMS. Many Acts and Rules relating to coastal and marine activities such as WPA (1972), EPA (1986) and CRZ (1994) exist in the country. In July 2004, to establish and exercise the sovereign rights on the biological genetic resources, the Government of India enacted the 'Biodiversity Rules' under the Biodiversity Act, 2002. The act mandates the following:

- The biological diversity in India is governed at three levels: Biodiversity Management Committee – Panchayat, State Biodiversity Board and National Biodiversity Authority (NBA).
- It provides free access to all biological resources by all Indian citizens and rights to use these resources for the purpose of research within India. However, on-Resident Indians and corporate bodies not registered in India have to seek prior approval of the NBA.
- Non-commercial bio-survey and bio-utilization related to research in India is freely allowed for Indian citizens. Similarly, it is not allowed for Non-Resident Indians, corporate bodies etc., without prior approval of NBA.

- For all Indian citizens, except local people and local community of the area, prior permission from the concerned State Biodiversity Board is essential for commercial utilization with a collection charge. Similarly, prior approval of NBA is essential for Non-Resident Indians, corporate bodies etc.
- No person (Indian citizen included), without prior approval of NBA, shall transfer/resale any research or Indian bioresources or associated Traditional Knowledge (TK) to any non-Indian citizen. Transfer does not mean disclosure is in compliance with the guidelines of the government of India on the matter.

Although marine ecosystem has larger coverage than other ecosystems, there are too few marine protected areas. Only 100 of the 1162 national parks of United Nation List include or adjoin reef ecosystems. In India, only four out of the 504 protected areas (National Parks 86, Sanctuaries 448 and Biosphere Reserves 7) are with reference to marine ecosystems. The protected areas (a total of about 102) of the Andaman & Nicobar Islands cover substantial areas of marine waters also.

Despite these, Indian marine and coastal ecosystems are facing many threats and pressures, the major being

- ❖ Habitat loss due to degradation (natural and anthropogenic)
- ❖ Intense overexploitation.
- ❖ Pollution and sedimentation
- ❖ Species introduction
- ❖ Climate change

#### **Strategies for conservation and management**

Conservation of marine biodiversity in India, can be achieved by the following guidelines:

1. A clear knowledge of our existing resources.
2. Application of anthropogenic objectives of maintaining biodiversity so that it is of value to humankind.
3. Local people priority to be recognized.
4. Revitalising the 200-year tradition of marine biodiversity inventorying to interpret, manage, conserve and use biodiversity in a sustainable manner.
5. Identifying how and what should be conserved.
6. Reconstruction of lost habitats.
7. Reduction of discards, by-catch being thrown overboard during fishing.
8. Establishment and management of Marine Protected Areas.
9. Ecosystem-based fisheries management.
10. Formulation of effective policy measures.
11. Economic valuing of biological resources in the ecosystems

#### **Conclusion**

The biodiversity of many habitats is under threat and, although seas cover the majority of our planet's surface, far less is known about the biodiversity of marine environments than that of terrestrial systems. If we have a clear idea of the diversity of a wide range of marine habitats and what controls it, we have better

scope of conserving biodiversity, or determining the impact of human activities such as mariculture, fishing, dumping of waste and pollution. Therefore, recognition of the scale of problems, the nature of the underlying causes, and the limited resources available to counteract powerful destructive trends will lead to the best way of conserving the marine biological diversity of India.

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